Menlo Park Notebook #37 [N-79-07-07.1]

This notebook covers the period July 1879-May 1880. Most of the entries are by Francis Upton. There are also entries by Edison. The book contains numerous notes by Upton relating to articles in technical journals, including notes on an article by John Hopkinson on generators, which appeared in the May 9, 1879 issue of Engineering, and draft letters to the editor by Edison and Upton concerning this article. There are also notes, calculations, and occasional drawings relating to dynamos and electric power distribution; notes by Upton on a proposal by the Holly Water Works Company to supply engines; and notes on "Laws of Winding Dynamo Machines." The label on the front cover is marked "Upton," "Statement as to power & c," and "Electric Light." The book contains 284 numbered pages.

Blank pages not filmed: 42-43, 136-139, 230-231, 236-237, 248-249, 260-283.

Burglar Machine 176

LIBRARY OF THE

BOARD OF PATENT CONTROL,

120 BROADWAY, NEW YORK.

_____, 189_

#37

128 lb

1000 Lamps 100 ohms each

Every 10 lamps of 10 ohms there is two conductors total R of 1 ohm

Cost 1/4 mile $30 per house a year 70

217
25
1085
434
5425

1000 feet

.3

T69/4

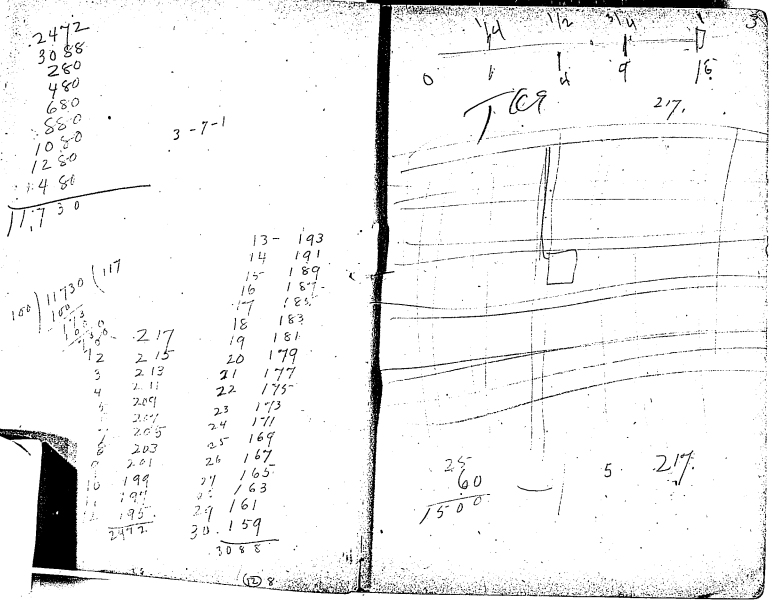
1/2

3/16

1320
20
132,00

264.16

2640


2472
3088
260
480
680
880
1080
1280
1486
11730
3-7-1
117
100
217
215
213
211
209
207
205
203
201
199
197
195
2912
13 193
14 191
15 189
16 187
17 185
18 183
19 181
20 179
21 177
22 175
23 173
24 171
25 169
26 167
27 165
28 163
29 161
30 159
3088
1/4
1/2
3/4
1
0
4
9
16
TCR
217.
25
60
1500
5
217.

31 — 157
32 — 155
33 — 153
34 — 151
35 — 149
36 — 147
37 — 145
38 — 143
39 — 141
40 — 139

1480

41 — 137
42 — 135
43 — 133
44 — 131
45 — 129
46 — 127
47 — 125
48 — 123
49 — 121
50 — 119

1200

51 — 117
52 — 115
53 — 113
54 — 111
55 — 109
56 — 107
57 — 105
58 — 103
59 — 101
60 — 99

1080

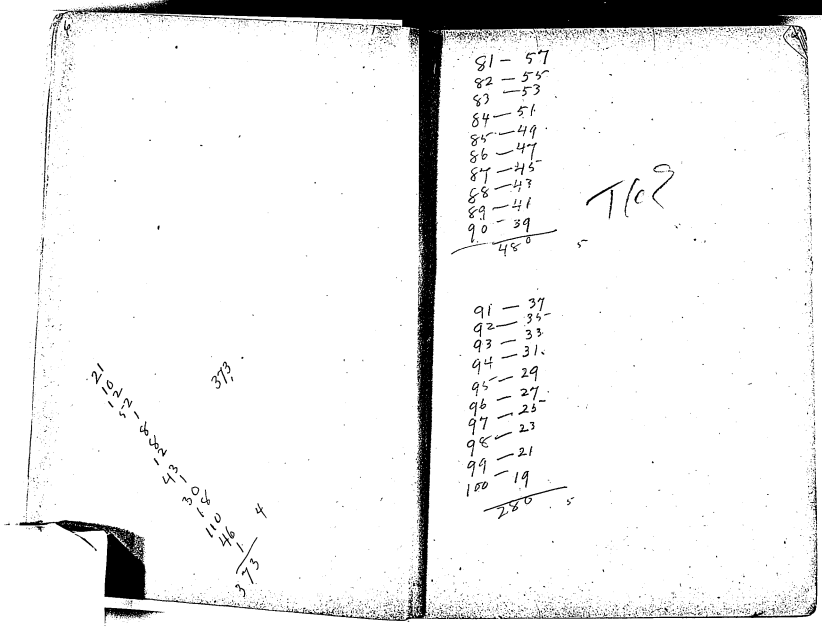
61 — 97
62 — 95
63 — 93
64 — 91
65 — 89
66 — 87
67 — 85
68 — 83
69 — 81
70 — 79

880

71 — 77
72 — 75
73 — 73
74 — 71
75 — 69
76 — 67
77 — 65
78 — 63
79 — 61
80 — 59

680

TOT


81 — 57
82 — 55
83 — 53
84 — 51
85 — 49
86 — 47
87 — 45
88 — 43
89 — 41
90 — 39
480
91 — 37
92 — 35
93 — 33
94 — 31
95 — 29
96 — 27
97 — 25
98 — 23
99 — 21
100 — 19
280
TCP
373
21
10
12
5
8
8
2
43
30
8
110
46
4
373

Thames embankment

Experiments Engineering 26 Oct 88 p 417

Fuel consumed per indicated H.P. 3.86 lbs of coal on a 20 H.P. engine

Power absorbed in driving engine and intermediate shafting 5.19 H.P.

Gramme machines 7.21
5.19
2.02 H.P

1 H.P. required to drive the Gramme machine at its speed

When the current was passing in the Gramme it took more power to drive the machine exclusive of the work done on the current

This is owing to the magnetic

34.17	1.53337
13.417	1.1277
2548	.4060
25.77	1.4110
12.57	1.0979
2.056	.3131
20.81	1.3183
12.08	1.0820
1722	.2363
17.44	1.2415
11.74	1.0697
1485	.1718
15.05	1.1775
11.50	1.0607
1308	.1168
13.27	1.1228
11.33	1.0542
1.171	.0686
11.19	1.0755
11.19	1.0489
1.084	0.0366

9.17 H.P
7.21
1.96 H.P. Tile

About 1 H.P. more required than this was measured & do not know. That is 2 H.P. consumed in driving each 9 running

13.17 H.P for 8 lights
9.17 H.P machine
5 H.00 H.P.
.8 H.P per lamp

13.17
7.21
5 5.76
11.17 H.P. including the machine

For Incline Dynamo

5 Lights	1.59 HP each
10 Lights	1.27
15 Lights	1.03
20 Lights	.90

Showing that there is a gain by subdivision of the lights.

10 lights

17.93
9.17
8.76 H.P. for 10 light
.87 H.P per light

TWR

15 Lights

20.75
9.17
15 | 11.58 (.77 H.P
10.5
1.08

20 lights

23.53
9.17
20 | 14.36
.716 H.P

Burned for night
5.5 hours

Coal .170 per ton TLE

48 cu. ft. of gas for 2 d.
per hour

48 for 4 cts

20.82
4
83.28

48) 1000 (20.82
96
400
386
140
8

1 foot cost
.083

83.28 cts per 1000 feet

5 foot burner
.083
5
.415

4.1 mills per hour

16

17

3.5 d for hours for

83 feet

7 cts

T. & E

83) 1.000 (12.04

83

170

166

4000

12.04

7

84.32 cts

exact per 1000 =

1 d 9 8.5

25

9

225

4.84

2.25

119

$ 7.28 per night

5.5 hours

23.53 N.P

23.53

5.5

11765

11765

129.415

9 | 7.28 (5.6
6 4 5
8 3 0

5.6 cts per hour per H.P

This is inclusive of attendance
rent Lamps &c

Material used
1 coal
getting of stone

3. 9.5
9
.3
1 7
6. 4.5

1.50
9
1.59 for material

129 | 1.59 (1.23 cts per hour
129
300
258
420

Conducting cable

£ 390

5

£ 1950

THE

2 Gramme machines Coal

£ 360

5

£ 1800

£ 900 each

42

43

Engineer testimony before Parliament ... M. 1221 p. 380

Mr. Samuel Hunter

40000 tons of coastal ...

4000 / 7 8 5 6 7 4000

1 2 8 9 1 feet of ... for ton

18 thousand ... feet for ton

... Protected ...

£ 400 ... capital

... 000 ...

71 5 6 7 0 0 0

357 ... feet ... dollar

357 on feet ... dollar

per year

24

55 to 74

X::
65 : X :: 74 : 55

65 / 55 / 275 / 2 / 3

74

74) 5775 (4
296
61

74

55 / 65 / 275 / 2 / 3
330
3) 5775

74) 5775 (48 3
592
185
592
3

25

10 cts a year interest
on 357 cu. feet

357) 10.00 (.028
714
2860
2499
361

TAG

.028 cts per cu foot
for interest

4 [illegible] =

£ 133.014 income
44.142 [illegible] including [illegible]
£ 88.872 expense [illegible]
5
£ 444.360

~~[illegible] 744.~~

The

715,570 thousand feet

715) 44400 (62 cts
~~[illegible]~~
4290
1500

Cost of gas 62 cts per 1000 feet

Mr. Farrer permanent
secretary of Board of Trade
Lights at sea
Lady Ford

1905 1d3

Houston & Thomas

.737 5/6

442.34

44.238 Yl. Hs.

Taf.

Used .12 chronometer galvanometer !

W0SIP3

42 1.6232
42 1.6232
2.08 .3151
44.3 1.6464

5.2109
162500 4.5185
32000 .6924

TW

4.92 H.P.

Engineering.
May 9, 1879.

No. 5

~~5.28~~
3.84
3.84
18.5

No. 5.

Ohms 3.88 Ohms a current of 18.2 Webers

8) 9
1.12
1.08

Tait
Volts

$W_1 = \mathcal{E} Q$

$Q = \frac{q}{8} \times \frac{a+b}{c} \times \frac{1}{c_2}$

$\mathcal{E} = Q R$

$W_1 = \mathcal{E} Q$

E. Mass Daniells taken as $\frac{q}{8} = 1.125$ Volts!

3.88	0.5888
18.2	1.2601
18.2	1.2601
1285,	3.1090

To find no need to convert Erg tens & Gilb

1.179 Erg tens equals	6
1.59 H.P	4
1.59	0.2014
38000	4.5185
	4.7199
52,470	.0714
1.179	4.6485
44520	

~~That~~ If in No. 5 E^2R is fulfilled we have 1285 as the number arising from multiplying them together, or that as of Erg sevens

38

The Siemens comments

86.4 of the energy into gives it in electricity exclusive of friction according to our measurements if a Daniell = 1.125 Volts or $\frac{9}{8}$

Hopkinson would have found that the Edison, which we made to give back 93% of the energy, gives back

96.7% of the energy over twice as good as the Siemens

39

To convert this into ft. lbs, Hopkinson used as multiplier 44,52 instead of 44.3 that I used TRC

1.125 Volts = 1 Daniell Hutchinson

1.08 Volts = 1 Daniell Ayrton

1.08	.0334
1.125	.0512
	.9822

96% of his measurements to be taken to equal ours

$\frac{96}{86.4}$ We should measure % of the energy converted by the Siemens exclusive of the friction

32
32
64
96
1024
.2
2048
44.5
10240
8192
8192
9113.60 ft lbs from 32 Watts on
.2 ohm

1.125
1.08
1.042

.0512
.0334
.0178

1.042 %

Remeasured 93%

93%

1042
93
3126
9378
96906

Then Hopkinson
method the Edison
a 96.9% machine

Your Journal of May 9
1879. Contains a paper on
Read before the Institution of Mechanical Engineers
Electric Lighting 1/1 by Dr John
Hopkinson F.R.S. in which some
very interesting tests on the
Efficiency of Dynamo
Electric Machines is described
In these tests the Siemens
Machine is set down as returning
~~to~~ giving to the circuit
90 per cent of the power
applied to the shaft.
I desire to call ~~the~~ attention
to the fact that the writer
has assumed the EMF of

1. 44%.
Houston Thompson
1.079

a Daniel Cell to be $\frac{9}{5}$ of
a volt, from which he
Calculates the Energy in
Current, while the value of
the horse power ~~output~~ should be Calculated
from a Daniel Cell having
an Emf of 1.08 Thus
This is as it is given by
Clerk Maxwell, and by Kohlrausch
at 109 —
taking the Daniel Element
at the Correct Emf. This would
make the Efficiency of
the Siemens machine
—— worked off ——
again 0.28 of a horse power seems
to be a large amount to run
the Gulcher without an open current,

again he uses a Calorimeter which he states to have a reputation of about [illegible]

It seems impossible from the number of experiments that the Calorimeter described & used, could have given correct results, such as the apparatus is directed to [illegible] owing to the small amount of fuel and Barometric Correction [illegible] this introduces [illegible] the error of unequal temperature between the Condenser & flue & he says a variation of 2° in favour of the higher Efficiency of the machine

If this is over estimated the Efficiency of the machine is still further reduced, H

Mr H's paper is of great value as the only test yet made on it is directed in a truely scientific manner and, I have no other object in calling attention to these, more difficult than that the true Efficiency of the machine should be ascertained in order that any one who may hereafter produce better results shall not have the paper and figures for the same; fictitious Efficiency quoted against him

To the
Editor of Engineering!

Sir.

In your journal of May 9. 1879, contains a paper by Dr. John Hopkinson F.R.S. M. Inst. M.E., giving some very interesting instructive results of tests of a Siemens machine. These tests show the machine to convert 90% of the power given it into electricity.

By these tests the machine appears to convert 90% of the energy delivered by the belt, into electricity

The power is delivered through a dynamometer and

The method pursued is as follows, the power absorbed is measured by means of dynamometer, and the energy of the current by calculating the electromotive force and a given resistance is calculated from measurements giving the electromotive force on a given resistance and the total resistance of the circuit, or from a measurement of the heat given off on the entire resistance or a part of the circuit by means of a calorimeter.

1 ft
100 ft

1/10 in
1/100

.03302
.03302
.03302
.05115
.98187
2
.96374
.9242
90
.831780

3/10 X12
3.6 inches
100 ft 1/100
3 X100
36 inches

I would call attention to the fact that the writer has assumed the E.M.F. of a Daniells as 1 & as 1.125 Volts. ~~Latimer Clark~~
The value taken by Messrs. Houston & Thompson is the same as that given by Mr. Latimer Clark on the authority of Prof. Ayrton. 1.079 Volts. as the energy is as the square of the no. of Volts, to compare the results given with those of the Franklin Institute they must be multiplied by $\left(\frac{1.079}{1.125}\right)^2 = .919 \quad .9242$. give The machine would be on this basis 83% of the energy back instead

Ohm too great
1.0196 absolute

There is as yet no reason why the German measurements should be taken and if for if they are considered correct the value of the Ohm must be changed to correspond.

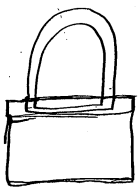
If the value 7/8 of the equivalent of a Daniells by some tests made on the new machine of Mr. Edison would give more than 100% of the power applied into electricity, and of this 7/8 may be made effective outside of the machine when the machine is consuming five H.P.

of 90%

If the German values ~~as given in Wiedemann~~ are ~~true~~

If Dr. S. Hutchinson's tests ~~Weber's determinations as given in Wiedemann Bands II. Part Vol. IV, section 1044, has stated~~ ~~between a standard of~~ ~~and 1.0000~~, ~~the Ohm should be~~ ~~by 1.0196 to~~ ~~said to substitute mean~~ ~~as determined by Weber.~~

Ohm The Daniells cell used was the gravity form, which has the E.M.F. of which is my best ~~1.1336~~ ~~more than~~ ~~less than the~~ standard Daniells with pure cup and concentrated solutions ~~thoroughly saturated~~ such as is described by Wiedemann.



5510 3.7412
44.3 1.6464
5.3876

244200

7.70 .8865
4.5185
5.4050

254000
5.3876
5.4058
.1722

93%

so that it seems strange to read in one place that the resistance was about 1/5 and in another that the resistance of the connecting wires was estimated at .01 ohm. When giving off [illegible] as in Ex. no. 12

I would also call attention to the fact that in measuring the heat by means of a calorimeter, a variation in the calorimeter, in the resistance of the wire, as given as above .2 of an ohm. A very slight error in the measurement of this would be greatly multiplied in the total. No allowance seems to be made for the fact that the wire must necessarily be much warmer than the water (in which it is immersed) and that its resistance would be increased by that much, thus making the machine show a greater efficiency than it ought to. For having a large res

T.S

It seems very important that some standard should be adopted for E. M. F. and as yet there is no good ground for taking other determinations than that of the British association. If those of Weber are employed corrections must be made for the fact that the ohm is not a perfect according to his measurements.

If the volume 1.125 Volts for a Daniells be employed in testing, a new machine of Mr Edison's shows that more power is given off as electricity

$$\frac{w_2 w_3 - w_1 w_4}{(w_1 + w_2)(w_2 + w_4) + w(w_1 + w_2 + w_3 + w_4)}$$

$w_1 = 10$

$w_2 = 1000$ 1000.5

$w_4 = 5$ 15

$w_3 = .052$ 16

~~$\frac{5000 - .8}{15000 + 2(1015)}$~~ $w_3 = 6$

~~$\frac{6000 - 5+}{16000 + 5(1016)}$~~

~~$\frac{5000}{16000} = \frac{5000}{17000}$~~ 4

Air is delivered to the machine.

$w_3 = 40$

$$\frac{52 - 50}{10006 + 1015} = \frac{2}{11021}$$

$w_4 = 6$

$$\frac{52 - 60}{10006 + 1016} = \frac{-8}{11022}$$

64

7.70

3 sec.

254000	5.4050
5.777	3.7612
	1.6438

44

7.70	0.8865
33000	4.5185
	5.4050

5.777

3.19	.5038
32.000	4.5185
	5.0223
2372.	3.3786
44.3	1.6437

In experiment No. 12

65

5.349	3.7284
44	1.6435
6	5.3719
235,600 .677	.8274
	4.5445

2 (1.345 / .677

35,010 ft lbs at least

35,000 ft. lbs. of energy given off from a wire 2 metres long and 1.5 mm in thickness.

2. .0015

.0015 3.14

.003

.00942 D m

94.2 □ centimetres surface

1.5⁻⁹ ,2014
33.000 4-5.185
4.7199
1179 3.0716
4.6483
0682
34
.0716 44.5

.168 ,2253
33.000 4,5-185
~~1.7068~~
4.7438
1263 3,10 15
43.9 1,6423

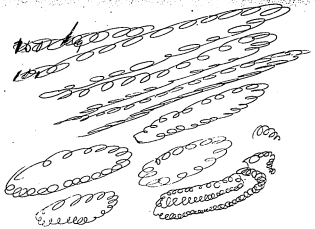
2.81 .4487
3,14 4,5-185
4.9672
0d 942 3,3234
2106 1.6438
44.0/5
.0020

cm = .392 in T .5933
T .5933
□cm = □in .153 T .1866

.153
94.21.9721
1.1587

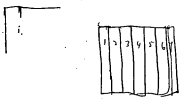
14.5
~~15.15~~ sq inches.

That is the heat of a large gas jet is given off from a surface of about 15 square inches. Ordinary experience would suggest to us that the metal must be considerably heated ~~for~~ ~~a~~ ~~small~~ ~~fraction~~ ~~of~~ ~~an~~ ~~inch~~ ~~or~~ ~~a~~ ~~couple~~ ~~of~~ ~~inches~~ ~~of~~ ~~the~~ ~~surface~~ ~~before~~ ~~boiling~~ ~~points~~.



1/8

Tried an experiment. A piece of German silver wire about a mm in diameter was immersed in water and a strong current passed through it.



76
14.5

If the metal was heated to boiling 170° ~~from the~~ ~~point~~ an error of about 2 0/0 would be introduced

It does not seem unreasonable to suppose as long as the heat was evolved from the middle of the wire that there may have been an average rise of 500° in the wire

1.00024
500
1.12000

That is a ~~rise~~ an increase of 12% in the resistance of the wire

1.5 mms
3.14
1.5
1570
314
4.710

.00471 m.
2
2 m. .00942 □ m.
.00942 m
.942 dm
94.2 □ centim.
94 □ Cm

5349 3.7284
5777 3.7618

In these 12 according .9666 to the ruling
the calculation

92% of the power given to the machines is converted into electricity. In the remarks the fact is mentioned that the belts were slipping. As any slip of belts would consume power in heating the ~~bearings~~ pulleys and belts a deduction would have to be made from the power indicated, so that 92% is probably much within the real per cent as read from the calculation

1.079 × 1.125 = 1.9819

.0330 + .0511 = .1841

95
90
92
90
9.80

.92 × .12 = 184 + 92 = .1104 → 81%

If 12% is deducted from the reading of the calorimeter only 81% of the power applied is given back as electricity

1.140 × 1.179 = .9887

.0569 + .0682 = .1251

97.4%

21.08 − 21.06 = .0108

.3340 − .3234 = .0106

2.903

102%

2.888 .4608
2.780 .1440
.0068

104%

2.903 .4629
3.538 .5474
.9155

82.3%

92 %

The per cent of energy interned in the shape of electricity from the calorimeter tests is in Ex

Ex. 4	97%
Ex. 6	102%
Ex. 8	164%
Ex. 10	82%
Ex. 12	92%

Two experiments out of the five showing more power

tests given and
The articles is by far the best
that have yet been published,
in that all the particulars under
which they were made are
stated, and the reader may ask
questions in the same manner
as if the apparatus were
before us.

~~And in this particular the~~
~~paper is by far the best one~~
~~that have yet appeared~~

in the circuit than in 77
The given to the machines.
and one is 15% from
the mean of the other four,
and one is practically worthless
on account of the slipping of the belts,
while all have a constant
error.

I cannot leave the paper
with only adverse criticism, for
criticism in itself is praise
of the fullness with which
the results are described. As a
reader I have found that I
can push in complete possession
of the facts for I have not
been able to ask any questions
that I have found answered in
a paper of this

decides having all the experiments of this ~~the~~ writer.

same accounts better than ~~a~~ kind is assigned as a series of experiments ~~performed by~~ made personally, for one can often see sources of error far clearer in watching another's work than in his own,

Yours Truly
Francis R. Upton.

Menlo Park N.J.
July 7, 1879.

80 1

28 AWG #48 1

The [illegible] of [illegible] -
[illegible] by [illegible]
[illegible] 28 AWG [illegible]
[illegible] turning the bobbin
[illegible]

100 Volts

25	1.3979
25	1.3979
4	0.6021
44.3	1.6469
	5.0448

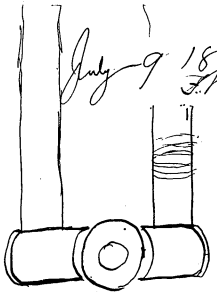
110 000

5 ohms 150

30 900
30 5
45 00 3.16532
44.3 1.6469
5.2996

199000

July 9 1879.



Trowbridge's article J. C.
Phil. Journal Vol 7 No. 42

In the galvanometer method he does not mention the fact that and takes for granted that a galvanometer of low resistance must be used in order to shunt of extremely low resistance. Though the method is faulty on account of the heating of the shunt, still it is applicable under the form of an electrometer method by using very high resistances. He speaks of the difficulty of measuring resistance by means of the galvanometer on account

of changes in the thermometer? In the electro dynamometer method he determines the constant by the aid of the instrument. This can only be used when the instrument is placed on a stone pier and [illegible] firm.

He speaks of the dynamometer being useful only for medium powers from [illegible] to very large ones, small ones the indications having very little value.

His estimates were made with the machines on almost closed circuit, and he mentions that the belt slip

8 30000
031
32000
99
1022.ans

206
33
618
618
6798

3265
33
984
984
10824

so much as to [illegible] recordings render this reading somewhat uncertain TOK

Estimates power required

from the armature of the Siemens on open circuit as 0.031 H.P
1022 ft lbs.
and the Gramme from 0.206
to 0.326 H.P.
6798 ft lbs to 10,824

How this limits are measured so exactly when there 40% difference between the extremes is hard to understand.

Hi speaks of the "equivalent of a Weber" as 102 metre-grams

102 / 136 × 60

23) 1020 (44.33
92
100
92
80
49
110

235 .3711 168 .2253
365 .5441 283 .4518
.8270 .7735

67 .336 .5263
45.3 .6561
.8102

163 .2122 309 .4450
298 .4782 553 .7967
.7380 .7417

254 .4048
644 .8089
.5959

That means that work done by a Weber in passing over an Ohm is 102 M-S- in a second or 44.33 ft. lbs. in a minute.

Wilde machine

Magneto run by a wire apparatus wire about the armature. The result was that when the machine was running on short circuit it absorbed less power. Reason, apparently when a strong current is passing, it changes the pole of the armature so as to [illegible] work it around about the magneto

62.33 | 1.7947
.594 | $\bar{1}$.7738
3702 | 1.5685

9830

.857 | $\bar{1}$.9330
43.82 | 1.6415
1.5745

.907 | $\bar{1}$.9576
60.25 | 1.7799
1.7375

1.039 | 0.0168
39.28 | 1.5941
1.6109

1.453 | $\bar{1}$.1623
44.94 | 1.6526
1.8149

328
2.3
984
656
7.544

7 lbs. of wire on armature for magnets.

TCG

21 lbs for the alternating arm - ments of the circuit.

The electromotive force varied greatly according to Trowbridge.

In circuit		E.M.F.	Speed	Speed reduced
.594	Ohms	37 Volts	548	67
.857		37.5	532	59
.907		54.6	500	74
1.039		40.8	520	55
1.453		65.3	520	56
2.305		75.4	528	39

If the current is a to and fro or alternating, it would seem absurd to speak of the number of Webers, [illegible] this energy [illegible] given to the [illegible]

~~rate change their~~ 166

If the currents change their direction they are constantly rising and falling so that there can be said to be no definite current on the line. Then as the dynamometer reads the square average of the squares of the currents, it cannot be without extreme accuracy of expression be said to measure the currents, for nothing is known as to the current strength. The mean equivalent should be introduced.

A ½ shunt of 0.1 Ohm was used in these measurements

2.7275 2.7832
2.1399 2.1399
48674 41.9231

675
341
334

.675 1.8293
86 1.9345
1.7638

760
341
419

.766 1.8842
75.6 1.8785
1.7627

781
341
440

.781 1.8927
75.6 1.8785
1.7712

509 .7067
589 .7701
.9366

442 1.6454
534 .7275
.9181

455 .6580
607 .7832
8748

81.300

.138
2.7701
2.1399
49100

Gramme machine (large size)

483 lbs of wire on magnets

Armature	0.129
Magnet	0.212
Total	0.341

Ohms	Circuit	Volts	% efficiency	
0.334 ohms	0.675 ohms	58	86.0 %	1
0.419	0.760	58	82.8	2
0.440	0.781	60.5	75	3

No 1 Mean
432 81.300 ft lbs commutation
2 466 73.600
2 452 83.800

The appearation of armature is here found, ~~in giving 6 figures~~ as 6 figures are given in the results of the horse power where two figures are probably not correct

2 on No. 2 with 0.760 Ohms

607 .7825
534 .7275
.0550

in the circuit 534.336 metre grammes running at 462 revs., while in no. 3 when running at a slower speed and having a greater resistance in the field 607.200 metre-grammes are consumed or nearly 14% more power where at least 2% less should have been taken, showing that in this case not even one figure was right.

100

.1973	1.9887	8312 .9196
79.8	1.9020	138² .1399
	1.8901	5.0395
1.055	0.6223	
68.8	1.8376	744 .8716
	1.8619	.1399
		5.0115
1.066	1.0283	839 .9238
66.	1.8195	.1399
	1.8478	1.0637

632	.8007	580	.7076
831	.9196	744	.8716
	.8811		.8360

472	.6739
839	.9228
	.7501

101

Siemens machine (Many exp.)

Wire carried around the [illegible] from armature. Eight divisions in the commutator

Resistance machine 0.5-86 Ohms

Speed at which it ought to run 370 - 380. Speeds in tests 264 — 325.

Resistance of circuit	Volts	~~Volts~~ unwrapped	
.973	77.5	109.000	1
1.055	72.7	102.000	2
1.066	70.4	110.000	3

	%
1.	
2	76.
3	68.5
	56.2

This seems to be an almost impossible result ~~for~~ for such slight changes in the speeds to make

such great changes in the 103
percent of power utilized.

A.

536	2.72792	536	2.72792
1076	3.0315	896	2.95523
	.6977		1.8769
454	2.6571	454	2.6571
1177	3.0710	1053	3.02254
	1.5861		1.6346
583	2.7657	583	2.7657
1242	3.0934	1092	3.0383
	.6723		.7274
376	2.5752	376	2.5752
970	2.98648	892	2.9504
	.2884		.6248
389	2.5899	389	2.5899
1285	3.1089	1175	3.0701
	.4810		.5198
438	2.6415	434	2.6375
609	2.7846	565	2.7520
	.8569		.8855

Houston & Thompson

per cent converted of power

	including friction	excluding friction
Large Brush	49.8	55.3 %
Small Brush	38	43.1
" "	47	53.4
Small Wallace	38.8	42.1
"	30.3	33.1
Thomson	71.9	76.8

Edison	90	94

A lt of coal an hour for
H.P

12000 # coal
1980 evap

38.000
60
1980,000

1200
198

1/6 of total energy utilized

Boyle Higgs p 175

1 cubic foot coal gas = 690
heat units when burned

772 2.8876
690 2.8388
5.7264
5.31000 ft lbs
5
2655,000 ft. lbs. for a gas
burner in an hour

2655 3.4073
1980 3.2967
.1106

129 H.P. evap is the
equivalent of a gas flame

1.29 at ex lights per
6 horse power
7.56

7.5 lights by means of
Rt from the same energy
as is used in a gas burner.

Franklin Institute

380 candles for H.P

15) 380 (25 gas jets
30
80
75
5

1 lbs gas coal produces
4 cubic feet of gas

12,000,000
2,112 4,000

5 31,000
2,112 4,000 ft. lbs

about 1/6 of the energy in
the coal in the gas.

In lb of gas coal there are 15000 units of heat

772
15000
3860
772
11,580 000 ft. lbs.

In coke 13.000 units of heat per lb
772
13 000
2316
772
10,03 6000 ft. lbs

Gas tar 20,000 units of heat in a lb
772
2
15,440,000 ft. lbs.

10,036,000
.85
50180
80288
8530600.00

15,440,000
.05
772000.00

1 lb of coal produces
4 cubic feet of gas
.85 lb. coke
0.05 tar

F. G

Coal 11,580,000 lbs. Gas 2,124,000
Coke 8,530,600
Tar 772,000
11,426,600 lbs.

Profit Loss 11,580,000
11,426,000
154,000 lbs.

3080 | 41165
14 | 11461
2.9704
365 | 2.5623
.4081 2.56 hours per day
24 hours a day

24 | 2.55
1

275
5
1375 | 3.1383
14 | 1.1461
1.9922

$98 capital a light

63
4
252

1760
150 jets

Estimate of Edison light July 10 1879

54
20
1080
10
1090
2
2180
1090
3080 pence per year
14

542 10s per year
for 14 lights

Paget Higgs estimates that the amount to be invested for a light Canopy by the Edison system as $98. 20 candle power 7 per H.P.

Estimate of the cost of working E.L. from a small power.

Boyet Higgs

£ 12/5 for full 2 H.P

$ # 60

60. 1,17782

365. 2.56223

9.21 99

16.14 d/c :: day

8.4 cts per day per H.P

3/4 ct for fuel per H.P

£ 15/5 oil & attendance

$ 75 1.87501

2.56223

9.3128 20.5 cts per day

10.5 per H.P

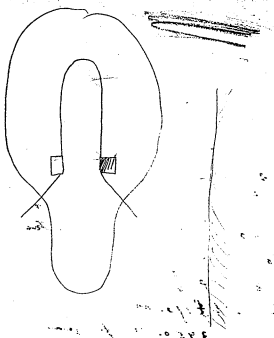
.5/6 ct per hour

10.5

8.4

18.9 cts per day of 12 hour

1½ cts per hour per H.P



In a ~~article~~ read before
Lecture delivered by Prof. W. E. Ayrton.
on "Electricity as a Motive Power"
I find the following facts as to
cost of power

In Sheffield.

~~£125~~ @ 500,000 tons of coal used for [illegible]
300 @ 750,000 " for melting
metals &c per year
~~£200~~ @ 150,000 " for heating gas
258 @ 250,000
1.650,000

Cost about £790.000
£3.950.000 per year

300
11
303
1800
183030 - 10 hours - day

17
3
61

Niagara Falls

100,000,000 tons in an hour
falls 150 feet
= 17,000,000 H.P.

Steam engine 3 lbs of coal per hour per H.P.

200,000,000 tons of coal a year equal to total consumption of coal for the world

Ayston

Best steam engine
2½, 3 lbs. of coal an hour
considerably less than a farthing
expense. One horse power
cost about 2d in a large
quantity, one single H.P. ¼.
na

Water motors.
1 cu. ft. 62½ lbs
½ descending 1 ft per minute gives approx.
1 foot lbs of work per second
That is 5½ cu. feet of water per minute
330 " " per hour
with 100 feet of head gives one
H.P. as practically a turbine gives
6.8 took we may say
450 cu. ft. of H_2O per hour
2700 gallons
produces 1 H.P.

Price in Sheffield

6d per 1000 cu ft

Cost of H.P. 1/4d per hour

1 shilling 4 pence

32 cts for H.P. per hour

52 gas jets 9 candles each

9

468 candles 2½ H.P.

2.5 0.3979

33.000 4.5185

comp 468 7.3297

176 2.2461

4 33.000 4.5185

380 2.5798

19387 86 ft. lbs per candle

5600 Arangappani

Frang

Cost of E. L. Northern R.R. of France

see page 189.

176 foot lbs for a candle

former known expended was

say 1/3 in use

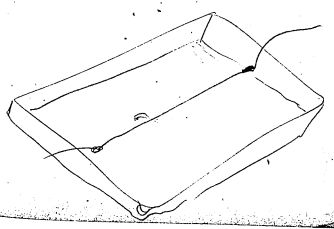
58 ft lbs Say

60 ft. lbs. per candle in use

Franklin Institute

ft. lbs per candle

in H. P. expended



Oct 13 1879

Holly Company will furnish a horse power for $90 and guarantee 2 lbs. of coal with a condensing engine. Boilers $18

Table

1 hour per day	365 hours per year
2	730
3	1095
4	1460
5	1825
6	2190
7	2555
8	2920

TOS

300 2.4771
2240 3.3502
1.1269
1.33

Coal $3 per 2240 lbs
1.33 mills per lb.
2
2.66 mills 2.66 cts. per hour

Compare the Hulby at $90
with an engine using 4 lbs.
of coal at $2.5 per horse hour

TUS

365 2.5623
266 1.4249
1.9872 97.7 cts

	1 lbs per hour	
1	$.485	$4.85
2	.971	9.71
3	1.456	14.56
4	1.941	19.41
5	2.426	24.26
6	2.911	29.11
7	3.196	31.96
8	3.681	36.81
10	4.850	48.50
16	7.76	77.69

Table cost of coal $8.00 per 2240 lb 133

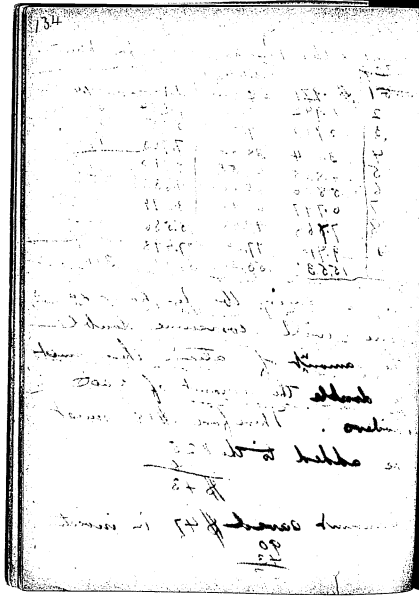
hours used	2 lbs per hour	2 lbs per hour capitalized	4 lbs per hours
~~365~~ 1	$.971	$9.71	1.942 19.42
2	1.942	19.42	3.884 38.84
3	2.913	29.13	5.826 58.26
4	3.884	38.84	7.768 77.68
5	4.855	48.55	9.710 97.10
6	5.826	58.26	11.632 116.32
7	6.797	67.97	13.574 135.74
8	7.768	77.68	15.556 165.56
10	9.71	97.10	17.498 174.98
16	15.53	155.30	31.11 311.10

As a four lb per hour engine will consume double the amount of steam there must be double the amount of ~~feed~~ boilers. Therefore $18 must be added to the $25

18
$43

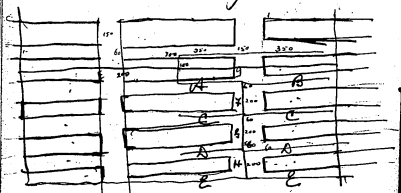
Amount saved $47 in investment

90
43
47



As two lbs. of coal per hour would be saved the minimum would occur when the capital to be invested equalled the amount to be saved that is at about five hours per day.

When the engine is used more than five hours a day $90 per H.P would be economised less than five hours $25. per horse power would be economical



180
900
750
15-30
60
200
179.0

40 ½ Half Block
220
240
60
102.0 Common

1020 by 10 ft
To 200 Lots

in block to Rabin

Holly estimate 1 square mile of city.

~~30 feet~~

Blocks in N.Y. 700 feet long
200 feet wide

24 lots on cross streets Hew city.
8 lots on avenues
Practice 30 on cross street
10 on avenue

80 houses in block

60 feet street

A	80 houses	250 feet	23 lb	0.123		
B	80 " "	810	1620	246 —	—	.393
C	80 " "	1070	2140	8586 —	—	1.038
D	80 " "	1330	2660	13260 —	—	1.293
E	80 " "	1590	3190	9480 —	—	.747
F	20 " "	1870	1000	620		.162
G	20 " "	600	1500	1088		.246
H	20 " "	760	2040	2694		.326
I	10 " "	1020	610	200		.065
		1400		361 0/4		4393/4
				144.404		17392

143

30 Lbs

7812
3
23446

1820

82.00
3 lbs
246.00

60 1070 2 2140

143 60 85.80

D 2660

E 221 60 13260

1520 2 3180

316 30 9480

760 2 1320 1302 20 2604 0

544 2 1088

900

2240 2660 20 4900 245 20 294

Use 2 cans

6 tons of coke

143

A	lbs 23		
B	246		
C	8580	10 days 12	
D	13260		
E	9480	365	
F	620		
G	1088	10.00	
H	2604		
J	200		

290 | 3 61 01 (1 5 1)

290 | 36101 | 124
290
710
540
1700

124 lbs per house

30
3720 per house at 3 o cts

Cost much more?

per house

per Camp &

per Camp & Conductors &

144

$5.00 $5.00
$5.00 $5.00
$5.00 $5.00
$5.00 $5.00
$5.00 $5.00 $5.00

5 1000 hours a year
5000 feet
$5.00 a year from a lamp

Average use Summer
7.30 — 10 — 2½ hours
5-00 — 10 — 5 hours
7½ 3.21
5½

$10.00
$2.00 per 1000 feet for capital
1/10 H.P.

145

1200 ohm lamps
10 per H.P.

$45 $4.5 $100
100

709

each street 950 feet 950
5
4750
1900
6650
4
26600
3200
29800
3200
33000 feet of trees on both sides of street

Avenue 800
4
3200

65
16
390
65
1010

$7000

$20

$20

$20

$20

$20

$20

$20

$20

$20

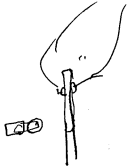
$20

$20

$20

$20

$20



148 May 8 1880

Winding machines

Present machine
110 Volts

~~Whittakers reservoir~~
~~Whittakers~~ Whittaker

Let x = resistance machine
y = E.M.F
C = no. coils
F = ~~length~~ Diameter of armature
L = Length of armature

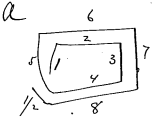
$y = C \times F \times L$

$x = \frac{C \times F \times L \times \text{Resistance wire}}{y}$

149

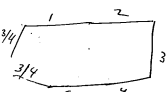
Two machines put together

A



8.5 = length

B



6.5 = length

A |:::| six wires

B |:::| twelve wires for first 1/2 the resistance

A .14 Ohm

B $\frac{.14 \times 6.5}{8.5 \times 2} = .046$ Ohm

17)77 (4.5
68
90

.045

$\frac{11}{34}$ of the natural resistance

1/3 the resistance

TUE

Present Armature

10 X 10

Surface

End 78.5

78.

314

470 sq in.

8 1/2 10 inch length.

85 inches of wire in loop

the wire is made up of six strands

.042 in cross section .001385 sq in

.011 covering 3

.053 Total 4155

.002206 sq in

3 wires 3

Solid .053 3 .053 3 .159 .159 1.48 1.5

.053 .053 .159 265 .00280 9 .00842 7

3 pcs 3 wires .008427 sq in.

.004155 sq in. Cu.

.004272

If square 5 2 9 6

.006216

20 inch = diameter

10 inches = length

Surface

314 78 1/2 312

2 312

628 312

628

125.2 sq in.

125.2

1252 3.0976

470 2.6721

.4255

2.6 times the surface

If the wire is square with .011 in covering

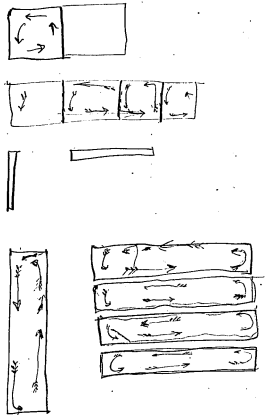
.006216 sq. in Cu may be put in the space

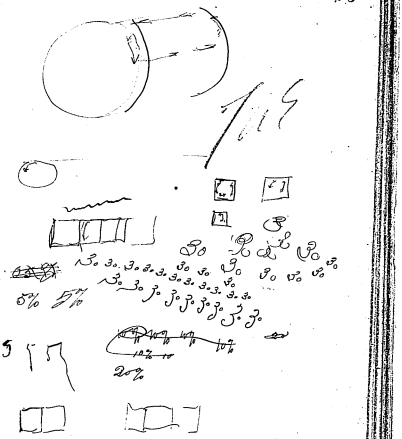
.006216 / .004155 = 1.5

.006216 / 4155 / 20610

.666 = 1/1.5

.66 .009 .00594





.20 inch armature
60 inches long.

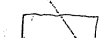
Wire 62.8 inches circumm.
39 commutators

62.8 1.7880
78 1.8921
T.9059

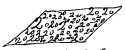
.80.5 in to coil Total
.055 for insulation
.750 cu. inch

.053
8
.424 .400 thick

750
400
.300000 sq in.



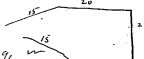
20



12) 3549 (295
24
1 18
109
96
13
74 feet

1.9X inches
39
819
273
12 354 9 inches
12
29 feet
72 feet

.3 sq. in.
section



.000000 854 sq in

Comp .300000 7854 6 8552
72 85773
993 930 99600
9.2263

log 9.936 — 0.9971
1000000 7854 — 1.8951
log .72 — 1.8573
comp .8 — 0.8229
3.2724

.00187 Ohms resistance of machine

00187

57
.159

120
960 | 1000

1000
960

1000

3.
2.9823
+.0177

20 | 1.404 Ohms
.0054

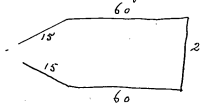
.00/0
.0005
.1
.005

.00187 | .000
.00187

160

Machine

6 magneto



30
60
60
21
171 inches around the armature or length of one coil.

12/171 (14.25 feet length of one coil
12
51
48
30
27
60

14.25	1.1538
39.	1.5911
2.7	8449

555.7 feet of wire

164

.3 sq. in. cross section.

Ohms	10.64
	.0000007854
log	555.7
Comp.	.3
	2.9888

1.0269	
7.8951	
2.7449	
10.5229	

~~4 | .009145~~ ~~.002436~~
4 | .01548
.00387

Resistance of machine ~~.002436~~ .00387 Ohms

Resistance 1000 lamps

.1 Ohm

$\frac{.1}{20} = .005$

$\frac{.1}{40} = .0025$

~~Do 40:1~~

comp	.1	1
	.00387	2.4123
		1.4123

25 : 1

Resistance 555.7 feet = ~~.009745~~ Ohms
= .01548

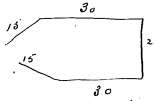
Resistance 1 ft. ~~.01548~~

$\bar{2}.1888$
2.7449
$\bar{5}.4439$

.0000278 Ohms

2.5 feet $\bar{5}.4439$
0.3979
$\bar{5}.8418$

~~.00695~~ Ohms
.000695



30
30
30
21
12/111 inches
9.258 feet around the armature

9.258
14.25

.009745 $\bar{3}.9888$
~~9.258~~ ~~1.9664~~
~~555.7~~ ~~7.2551~~
~~$\bar{3}$.2103~~

.009745 $\bar{2}.9888$
9.258 0.9664
14.25 8.8462
~~4|.00633~~ $\bar{2}.8014$
~~.0015825~~

resistance of the machine

4|.01003
.00251

Resistance 2.5 feet or 30 inches

.000695 ohms
X 4
.000278

$\bar{5}.78418$
0.60211
$\bar{4}.44439$

10 inches radius
10.45

1.
1.0191
1.9809

If 3 Volts ~~are~~ is the average E.M.F. then the is active between outside and inside of wire

3. $\bar{1}.4771$
$\bar{1}.9809$
0.4580

.45
10.45

$\bar{1}.6532$
1.0191

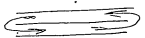
3.
.105

$\bar{2}.5441$
0.4771
$\bar{1}.0212$
$\bar{2}.0424$

$\bar{2}.0424$
1.6464
$\bar{1}.6888$ .488 ft lbs
Comp .00278
$\bar{3}.6561$
$\bar{3}.2449$ .000695 lbs

2.5 feet of wire ~~.002778~~

If it is assumed that the current, has to travel around the wire

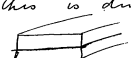


the resistance will be ~~twice~~ this four times this $\frac{.00278}{4} = .00278$

1760 3.2449
78 1.8921
5.1370

137,000 ft lbs.

If this is divided length-ways



in each half there will be 1/2 the E.M.F and twice the ~~resistance~~

or 1/8 of the power lost

8 ⟌ 137.000
17.125 ft lbs in each
2
34250 " " total

The there will be active on the whole $\frac{105}{2} = 105.2$ Volts on a resistance of

9.25	.9661
.0000278	$\bar{5}.4440$
.000257	$\bar{4}.4101$
4	0.6021
.00103	$\bar{3}.0122$
.052	$\bar{2}.7160$
	$\bar{2}.7160$
	1.6464
	2.9878
117 ft. lbs.	2.0662
39	1.5911
4500 ft. lbs.	3.6573

34,250
4.500
38.750

If again divided it would require 1/4 of this amount

4 ⟌ 38.750
9.687 ft lbs

10.000 ft lbs lost by local action, with four wires

Present machine

.042

10.042

10.42 1.0178

comp. .042. 18.3768

18.3768

3.7714

1 ft of wire .00591 Ohms

9.258 feet around the armature

48 wires

$\mathcal{E}$ = E.M.F. driving

$\mathcal{E}'$ = " " receiver

R = resistance circuit

$c = \frac{\mathcal{E} - \mathcal{E}'}{R}$

Work = $c(\mathcal{E} - \mathcal{E}')$

$= \frac{(\mathcal{E} - \mathcal{E}')^2}{R} = \frac{\mathcal{E}^2 - 2\mathcal{E}\mathcal{E}' + \mathcal{E}'^2}{R}$

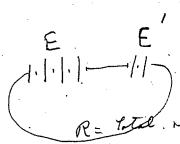
Work on resistance $= c^2 R$

$= \left(\frac{\mathcal{E} - \mathcal{E}'}{R}\right)^2 R$

$= \mathcal{E}$

1/4 the resistance

1/2 the E.M.F.



R = Total resistance

$c = \frac{\mathcal{E} - \mathcal{E}'}{R}$

$c = \frac{\mathcal{E} - \mathcal{E}'}{R}$

$c\mathcal{E}'$ = Work on ~~the~~ battery $\mathcal{E}'$

$c^2 R$ = work on resistance

$$\frac{\mathcal{E}'(\mathcal{E} - \mathcal{E}')}{R} + \frac{(\mathcal{E} - \mathcal{E}')^2}{R}$$

$$= \frac{\mathcal{E}\mathcal{E}' - \mathcal{E}'^2 + \mathcal{E}^2 - \mathcal{E}\mathcal{E}' - \mathcal{E}'^2 + \mathcal{E}\mathcal{E}'}{R}$$

$$= \frac{\mathcal{E}^2 - \mathcal{E}\mathcal{E}'}{R} = \frac{\mathcal{E}(\mathcal{E} - \mathcal{E}')}{R}$$

44) 200 (4.5
176
240

4.5 smaller for Cu Pt
but larger for Zn

3 smaller for Cu Pt
Brass

Total work = $\mathcal{E}c$

$c\mathcal{E}'$ = work useful

$c(\mathcal{E} - \mathcal{E}')$ = work on resistance

Distribution of work

$\mathcal{E}'$ to $\mathcal{E} - \mathcal{E}'$

THE

25 volts
25

25	1.3979	
25	1.3979	
44.3	1.6464	
		4.4422

27700
11080 00

$$\frac{d\,\frac{\mathcal{E}\mathcal{E}' - \mathcal{E}'^2}{R}}{d\,\mathcal{E}'} = \frac{\mathcal{E} - 2\mathcal{E}'}{R}$$

$\mathcal{E} - 2\mathcal{E}' = 0$

$\mathcal{E} = 2\mathcal{E}'$ maximum

3 magnets

.00591	3.7714
9.258	.9665
39	1.5911.
comp 4	9.3979
	1.7269
comp 48	8.3188
	2.0457

.0111 Ohm if wound with wire four wire deep.

.00555 Ohm if wound 8 wires deep

120 H.P. in the current 8 lamps per H.P.

960 lamps 2

7.0176

Resistance multiple are 1.0176

.1041 Ohms

Conductors .0104

20) .1145

.00572 resistance of machine 20 : 1

Heat on machine

Surface of present machine page 152 470 sq in from this can be taken 75 Lamps about 85 Ohms each for two hours

85 1.9294
75 1.8751
.0543

1.133 Ohms multiple arc
.113
1.246

reactance of machine
.14 Ohms

1.246 .0955
.14 1.1461
.9494

8.9 : 1 ratio total outside

.0543
1.1461
.9082

8.1 : 1 ratio Camps

75 Camps 8 per H.P

75 1.8751 ∠
8 .1031 ∠
9.37 H.P .9720 ∠
.9082 ∠

Machines .0638 ∠
1,115 H.P 4.5185 ∠
33000 4.5823

38.200 ft lbs from armature

4.5823
4.70 2.6721
75 Camps 1.9102

81.3 ft. lbs. per sq in.

60 Camps

3600 3.5563
cond 5625 6.2499
81.3 1.9101
52 ft lbs 1.7163

page 176 20 inch

Surface 20 in X 30 in

Ends	314.
	314
62	1860
30	2488 sq in
1860	

Multiplaces R .1041	T.0176
.005555	3.7443
18.7 watts	1.2733
H.P 120.	2.0792
	1.2733
6.4	.8059
Comp 2488	4.5185
	6.6047 1.1226
	1.9285

84.8 ft lbs per sq. in.

Recapitulation 10X10 armature

surface 470 sq. in. to 1.5 H.P.

When taking 75 lamps from this surface about 85 Ohms and 8 per H.P. in current

81.3 ft. lbs given off from each sq. in of armature.

20X30 inches armature

surface 2488 sq. in

wound with 8 deeps of .045 in. wires Resistance .005555 Ohms.

120 H.P in current gives 84.8 ft lbs per sq. inch of surface

That is if a machine can be built which shall give the E.M.F required.

280 lbs. bar back
700
280
1260
3 magnets
3780 lbs

20 in
3.14
20
6.28
78
.805

1.7980
1.8921
1-9059

12 wires

.048
6
.054 wire
12
108
54
.648

.048
.011
.059 wire
12
118
59
.708

.042 $\bar{2}$.6232
.042 $\bar{2}$.6232
3.14 0.4969
96 1.9823
$\bar{1}$.7225
.6021
4 .133 $\bar{1}$.1235

There is .805 in sphere
for winding 20 inch armature

.048 wire
6 coverings
.054 fills .648 in

39

.048 .059
8
.472

3/472
19.66
4
78.64
11
67.64

78.64 - 4858
67.64 3593
54
14372
1796.5
.194022

.048 1810 wires
96
10860
162900
17376.0
.048 wire

.642 wire .133

Gross section .468 wire

144.173 :: .00555

2.7443
3.2380
7.7122
3.6945

.00496 Ohms

1.0176
3.6945
1.3231 21.11 Ratio

2.0792
1.3231
.7561 .5 H.P
1.1226
1.8787 75.6 ft lbs per sq in

117 wire

10751
24
43004
21502
258024

258.173 :: .00555

2.2380
3.7443
7.5884
3.5707 .00377 Ohms

1.0176
3.5707
1.4469 2811 Ratio

2.0792
1.4469
.6323 4.3 H.P
1.1226
1.7549 56.8 ft lbs per sq in.

Wind with No. 11 wire

.120 24 strands to

Commutator

120
6
.720

Resistance 0

.109	$\bar{1}$.0374
.109	$\bar{1}$.0374
3.142	0.4972
comb 4	9.3979
.00933	$\bar{2}$.9699
24	1.3802
	$\bar{1}$.3501

224

059
2
118
11
107

No 12.109

8992

.0093.31
24
37324
18662
.223944

223 : 133 :: 100 : 59.7

2.7235
$\bar{3}$.7443
7.6517
$\bar{3}$.5175 .00329 Ohms

$\bar{1}$.0176
$\bar{3}$.5175
1.5001

31:1 Ratio

2.0792
1.5001
5791
1.7226
1.7017

3.84 H.P.
per sq. inch
50.4 lbs

184

To save 1 H.P.

2 cts per hour
5
10 cts per day
$36.50 per year
365 capitals

Wt Cu. wind

	.02239	T.35500
$163	9.258	0.96655
	12.	1.07792
	39	1.59111
	.32	T.50051
	310 lbs	2.49199
	.85	T.50441
		2.03660

$108

.765
.0625
.7075
66
6|637
106

16)100(6.25
96
40
32
8

1.75
16
5|637
1274
4
.5096

1.7871
1.6911
.7960
.3010
.8750

.805 space at 20 inches

.785 space in 19.5 inches

.109
6
.654
66
.720
625
.095

.109
4
.436
44
.480
.180
.020
19.500

.1059
4
236

No. 12 wind fills space 785

20.510 inches

allow .04 for space between walls

make opening 20.5 inches

No. 12 .109 in. diameter

If the machine is made 19.5 inches diameter of armature this can be easily put in place. The resistance of the machine will be .0043 ohm on 24.2:1 as the ratio when 960 lamps are on.

4.9 H.P. will be lost on the armature or 65.7 H.P. per square inch.

□ square is $\frac{4}{3.14}$ times the circle

120	.14400
109	11881
104	
484	
100	
11881	

144 7.8.4115
119 2.1075
4 0.6021
.5191

3.3

Though space could be economized by using square wire 9 prefer to use round wire. Round wire is not apt to bruise at the ends and it can be far better wound and managed.

9.258 | 0.96655
39 | 1.59111
361 feet | 2.55766

Total wire 4X6 = 24 wires

24 | 2.55766
Total 8670 feet | 1.38062
ft per M. 2.78 | 3.93828
311 lbs | 1.44446
| 2.49382

calculated from Prescott

310 lbs calculated from cross section

311 lbs | 2.49382
Ohms per M. .0242 | 2.38382
comp 24 = 96 | 8.01777
comp | 2.89553
comp 24 | 8.61948
| 3.51501
.00328 Ohms

109
104
981
109
11881

1764 | 3.24654
96 | 1.98232
169300 | 5.22886

11881 | 4.07494
24 | 1.38062
285000 | 5.45549

285) 169.00 5-5-5 ÷ X

3.74443
2.22792
7.54553
3.51773

.00329 Ohms

small machine

9.258
3.333 = 40 inches
5.923
1.666
4.257

.592
75

Coeffs
296

comps 6
75
1.49
.005 85
2 1 3

1. 8751
7. 6902
3. 7672
1 3325

4.26 X 2 X 75 X .005 85
4 X 6
2

4.26
75
.005 85
comps 12

1.6294
1.8751
3.7672
2.9208

.155 Ohms 1.1925
3.7672
1.4258
.004 31
3.6345
.115 Ohms 1.0598

39 turns
30
1170 inches

90 1.9542
1170 3.0682
2.8860

.076 Volts per inch

May 25 1880

600
5400 54 Volts from present Large machines at 600

54
2
108 if two turns

JWE

May 25 1880

20 inches 62.83 circum.

100 H.P.

8 lamps for 3 lbs of coal

3 : 2.5 :: 8 : 6.66

8

3 | 20.00

6.66

Lamps per indicated horse power on the engine

100 horse power will give

666 lamps in running

Resistance 700. Each lamp to have 100 Ohms on an average when hot.

7 | 100

.1428

May 25 1880

9 Volts from 20X10 machine at 100 revs by experiment

21.5 Volts on one quart

21.5	1.3324
21.5	1.3324
4.43	1.6464
1.94	9.7122
10.5200	4.0234
	4.5185

3.1 per H.P. .4951

If the distance is increased to twice as great 6.5 Volts may be taken as the amount native. 6.5 X 3 = 19.5 Volts large machine. 600 revs = 117.0 Volts

6

117 : 90 :: 75

	1.8751
	1.9542
	7.9319
57.7	1.7611

57 commutator blades

May 25 1880

Df Book 81 page 104
page 122 & 112

940 : 602 : 1625 : 400

2.7959
2.7789
1.0269
2.6017

No. 3	750 turns	43 Volts
No. 2	600	120
No 2	750	150 Volts

No 2 6 layers 39 coils
6
234 turns

No. 3 75 turns

	150	2.1761
No. 2	234	2.3692
		1.8069

.64 Volt per 2 turns
.32 per turn

May 25 1880

No 3 43 1.6335
75 1.8751
1.7584

.57 Volt per turn

.62 Ohm resistance No 2

Two layers 75 commutators
multiple arc = .14 Ohm
4 layers series = .56 Ohms

39 commutators

39	1.5911
75	8.1249
.56	1.7482
	1.4642

.29 Ohm
Df 6 times around 6/4 X .29

4 1.29
.0725
6
.4350
2
.86 Ohm

No. 2 probably wound 12 times around the commutator

$\frac{.64}{2}$ Volts to a turn

.32 Volt

600 : 525 :: 120 : 105

$\frac{.2}{1050}$

140 volts on No. 1 at 525 rev

525 : 750 :: 140 :

200 Volts

2.14 61	
2.87 51	
7.2797	
2.3609	
2.3692	
.1937	.19717

.468 Volts per turn

Distances iron from iron

		Volts per turn
No. 1	.81	.468
No. 2	.94	.32
No. 3	.16	.57

Everything is so mixed that it is impossible to tell without experiment what to decide as to the influence of distance of iron of armature from face of magnet in the E. M. F.

Tal

700 lamps in multiple
are given .1428 Ohms of
Machine as wound 39 coils

19.5	1.2900
39	1.5911
76 Volts	.88.11

In round numbers
3/2 the number of coils
9/4 the resistance

4/.00329 Thurs p. 189
.000822 5
.0079025

1428/20 = .00714

.1428	T. 1567
.0074	J. 8692
19.4 6 1	1.2855

200

60 light

62 (478

7.83 sq. inch to lamp

52 ft. lbs per sq. inch

700) 24.88

35.5 sq. inch. to lamp

45 ft. lbs per sq. in.

201

19.5 inches 1.2900

3.14 .4471

61.2 inches 1.7871

.109 nine

4

.436

1/16 .062

.498

.44

.542 1.7871

1.7340

2.0531

113

5 6W coils

7.00 0.8451

comp 6.66 9.1761

100 2.100 ww

33000 4.5185 6.5397

Comp 20.4 8.6904

170.000 5.2301

.176 2488 3.3959

68.4 1.8342

page 175 10 inch machine

By experiment Chicago 2.9

8 Volts from machine
running at 100 ~~0000~~ R.P.M.

$\frac{\overset{59}{\cancel{60}}}{24}$ Volts large machine

$\frac{6}{144}$ Volts 75 commutator

144 : 90 :: 75 : 46.9

	1.8751
	1.9542
144	7.8416
	1.6709

47 turns

5 miles

109

545
055
062
862

6

61.5 inches circum

61.5 × .662 = 1.7871 − 1.8209 = .9662

2) 92.5

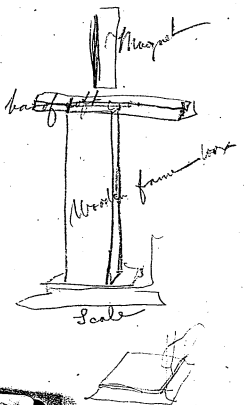
46.2 turns

If the machines pulsings
this is running very close

90 volts maximum effect

709

Experiment to be tried



Move the magnet along the bar and see if the attraction is not stronger in the middle than at the ends, by seeing how much weight is taken off

Plot curve of ~~the~~ magnetic taking Webers X No. turns as basis

T.E.

47^2 1.6721
1.6721

Comp 39^2 8.4089
8.4089

.00329 $\bar{3}.5172$

.00477 $\bar{3}.6792$

μ .199 A .1428 $\bar{1}.1547$
.00477 $\bar{3}.6792$
1.4755

Ratio 29.9 : 1

μ 201 A 6.5397
30.9 1.4900
112000 ft. lbs. 5.0497
3.3959
45 ft.-lbs. μ eq. incl. 1.6538

51 commutators decrease size of wire

5-13

1.7076 L 0

5.1228

5.3279

5.3279

3.6792

1.4578

8.3279

.0061 ohm 3.7857

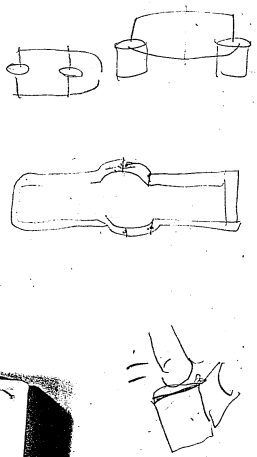
.6792

5.1065

1.0538

7.03

5716 ft. lbs. per sq. inch



6 | 33000
5500

Friction 1/2 4500
1/2

33000
8
2 | 264000
22000

14
~~14~~

22000
44000
4 | 22000
5500
4
22000

3 1/2

5057
3
15171
2526
17697

.87

5057

100
100
10000
441
40000
40035
44000
435
435
609
41

.87 | 5057.00

Friction balance. The 5500 ft lbs

Saving 1 armature,

.2200

14

TAF

11

4 ohm. 48

1 ohm

22000.

.14

Total 3½ armature

1.68 outside

1.6

17697

bottom armature

5½ 100

.84

3½

21
84

47 commutator No. 12 wire = 0".109 inch
.011" covering

Iron of armature 19".5 = D

19.5 circum 61.26 1.7872
47 X 2 = 94 1.9731
0".652 1.8141

Each division 0".652

5 wires $\frac{109}{\frac{11}{120}}$ $\frac{5}{600}$ wide

4 wires $\frac{120}{\frac{4}{480}}$ $\frac{2}{960}$ deep

Surface 19.5 inches diam

298.6
298.6
1837.8
2435. sq. in
245.0 sq. in.
20.46

Ends

61.26
30.
1837.80

TAB

329.
329.
1929.
2587. sq inches
26.00 sq. in

30 inches long
13 inches to reach from commutator to end
10
53
2
106. inches length coil

2290 To reduce to 2000 turns

Multiply E.M.F. by Wrong

2000
1698

Book 48 p. 113

3.301
3.2298
.0712
.0718
7.9995
8.1425

6.0718
7.9995
8.0713

Constant to reduce E.M.F to 25-20 f.p.m cutting speed and unit of wire with 2000 turns on magnet.

Armature Speed

Let A = r.p.m. armature
x = constant to multiply Emf or speed by to give this Emf at 2500 f.p.m.

$3.14 \times \frac{5}{12} \times A = \text{f.p.m. armature}$

$X = \frac{2500}{\frac{5}{12} \times A \times 3.14} = \frac{6000 \times X}{A \times 3.14} = \frac{1910}{A}$

6000

3.7782
.4969
3.2813
7.7905
0.0718

B
1910
Book 39 p. 15 Comp A 1620
1.18

Small wrought iron motor 291

Magnet Book 48 page 113

Turns 1698. 3.2299
Resistance 6.8 0.8325
25 2.3974

Constant to multiply Volts on magnet by to obtain Webers X No. turns. Webers from Volts

9.1675

Armature Book 48 page 118

37 Commutator Strokes
6 turns
4.5 inches
1.6666
0.7781
0.6532
3.0005

1000 inches of wire active on each side

Comp 6.9995

TAE

On magnet

4/12 #

	2.6149		184	1.5315
	2.3974			8.0713
1030	3.0123		.0401	8.6028
	1.47	.8109	42.3	1.6263
		2.3974		8.0713
1610		3.2083	.0498	8.6976
	7.61	.8814	47.3	1.6749
		2.3974		8.0713
1900		3.2788	.0557	8.7462
	8.73	.9410	50.6	1.7042
		2.3974		8.0713
2150		3.3384	.0596	8.7755
	10.8	1.0334	56.3	1.7505
		2.3974		8.0713
2700		3.4308	.0664	8.8218
	11.9	1.0755	59.6	1.7752
		2.3974		8.0713
2970		3.4729	.0702	8.8465

From armature

	15.2	1.1818	63.6	1.8035
		2.3974		8.0713
3800		3.5792	.0750	8.8748
	18.6	1.2695	67	1.8261
		2.3974		8.0713
4600		3.6669	.0789	8.8974
	31	1.4914	72	1.8573
		2.3974		8.0713
7740		3.8888	.0848	8.9286

TAE

.135 T. 1303
2.34 2.3692
amp 12 8.9208
2.63 .42.03

91
45
136

2.34 2.3692.
6.18 0.7910
3.14 0.4969
6. 0.7782
comp 17.37 6.7620
156 1.1953

Magnet reduction to 2000 turns

2000 3.3010
Both 41.33 1404 3.1473
.1537

Regular Core and Yoke

Armature

Length of armature 9"

2 X 75 = 150 turns
9
1350 3.1303
comp 1350 6.8697

Constant to reduce S. M. F. of machine to inch of wire on the armature

Magnet 1404 3.1473 TAE
comp 1.4 9.8539
1001 3.0012

Armature speed page 220

$X = \frac{2500}{\cdot \pi \text{ A } \frac{9.73}{12}} =$

Webers from Volts

9.8539

$A = 1048.$

$$X = \frac{2500}{3.14 \times 1048 \times \frac{9.73}{12}}$$

$$= \frac{27000}{3.14 \times 1048 \times 9.73}$$

0.4969
3.0204
0.9887
4.5054
4.4314
1.9260

$X = .843$

1.9260
4.8697
4.7957

Magnet

.952

Ratio 103 1.93

1.4786
3.0012
2.9798

954

Armature

16.3

1.2122
4.7957
2.0079

.0102

Magnet

1.14

0.0569
3.0012
3.0581

1140

Armature

22.2

1.3464
4.7957
2.1421

.0138

TAF

228 Magnet

1.561 → 3.0012 × 0.1934 = 3.1946

1560

dometure 3.2

1.5051 → 4.7957 = 2 3008

.02

1.862 → 0.2695 × 3.0012 = 3.2707

1860

39.3

1.5911 → 4.7957 = 2.3868

.0254

2.31 → 0.3636 × 3.0012 = 3.3648

2310

49.3

1.6928 → 4.7957 = 2 4885

.0307

3.612 → 0.5578 × 3.0012 = 3.5590

3620

73.3

1.8651 → 4.7957 = 2.6608

.0458

5.13 → 0.7101 × 3.0012 = 3.7113

5140

89

1.9494 → 4.7957 = 2.7451

.0556

TAS

Change of commutation

3.06 → 0.4857 × 3.0012 = 3.4869

3060

97

1.9866 → 4.7957 = 2.7826

.0606

Magnet to reduce to 2000 lines

Multiply E.M.F. Armature by

2000 / 1752

3.30103 / 3024 3

.05

7.1707

.6790

Magnetic

7.8497

Book 48 p 257

large 20" machine

Armature

To reduce to inch of wire

9 turns

75 turns

675 inches of wire active

comp 675, 7.1707

Magnet

To reduce Volts to Webers

multiply by 1/1.94 9.7122

1752 3.2435

9.7122

2.9557 TAE

Armature speed

$$X = \frac{2500}{\frac{20}{12}\pi A} = \frac{2500}{\frac{5}{3}\pi A} = \frac{1500}{3.14\,A}$$

3.1761

0.4971

478 2.6790

comp A 10 8.

.6790

Magnet Volts		Armature Volts	
1	2.9557	1.9	.2788
			7.8497
903.		.0134	8.1285
2.	.3010	3.9	.5185
	2.9557		7.8497
1810	3.2567	.0233	8.3682
3.	.4771	4	.6021
	2.9557		7.8497
2700	3.4328	.0283	8.4518
4	.6021	4.7	.6721
	2.9557		7.8497
~~3.58~~	3.8578	.0332	8.5218
~~3610~~			
5	.6990	5.2	.7160
	2.9557		7.8497
4510	3.6547	.0368	8.5657

10	1.	7	.8451
	2.9557		7.8497
9030	3.9557	.0495	8.6948
15	1.1761	7.8	.8921
	2.9557		7.8497
13500	4.1318	.0552	8.7418
20	1.3010	8.1	.9085
	2.9557		7.8497
18100	4.2567	.0572	8.7582
30	1.4771	8.25	.9165
	2.9557		7.8497
27090	4.4328	.0584	8.7662

TAE

Laws of winding Dynamo Machines

The resistance with A coils is R.

If the thickness of the wire be increased n times the resistance will be $\frac{R}{n}$

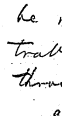
That is the wire will be n times as thick.

If the number of commutators be increased the cross section n times if the depth of wire remain the same and the width of the wire only decreases the resistance will be $n^2 R$. The current will travel n times as far through wire of $n^2 R$ resistance

If at the same time the thickness of the wire be decreased it will give a resistance of $n^3 R$.

If the size of the armature be changed so that it has a diameter n times as great, same thickness of wire. Length = 1. Diameter = 1

Wire n times as wide the length will = n + 1



TAE

940

The resistance will be $\frac{(n+1)R}{2n}$

If the length of the machine be made n times as great diameter remaining the same the resistance will be $\frac{(n+1)R}{2}$

If both diameter and length be altered the resistance will be R

Change of E.M.F. = E

n times the commutators

E.M.F = $n \cdot E$

n times the diameter

Machine proportioned same E.M.F = $n E$

of same number of r.p.m. 24

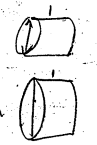
If same cutting speed

E.M.F = E

If n times the length of bobbin the E.M.F will be $n E$

The surface of armature = S

n times the diameter



TAE

$\frac{\pi n^2}{4} + \pi n :: \frac{\pi}{4} + \pi : S^1 : S^n$

$S = \frac{\left(\frac{\pi n}{4} + \pi\right) n}{\frac{\pi}{4} + \pi} \cdot S$

$= \left(\frac{\frac{n}{4} + 1}{\frac{1}{4} + 1}\right) n S = \left(\frac{n+4}{1+4}\right) n S.$

Surface $= \left(\frac{n+4}{1+4}\right) n\ S$

If the length be increased n times the diameter the same

$\frac{\pi}{4}+\pi : \frac{\pi}{4}+\pi n :: S : S'$

$S' = \frac{\frac{1}{4}+n}{\frac{1}{4}+1}\ S$

$= \frac{1+4n}{1+4}$

If length and diameter be increased n times

$S' = \frac{\frac{\pi n^2}{4}+\pi n^2}{\frac{\pi}{4}+\pi}\ S$

$= n^2 S$

General

No. Turns $= n$

Length $= a$

Diameter $= b$

Cross section wires $= c$

Resistance $= r$

E. M. F. $= e$

Surface $= s$

For another machine

No. Commutators $= n$

Cross section $= d = \frac{rc}{R}$ (1)

Resistance $= R = \frac{rc}{d}$ (2)

E. M. F. $= E = e$

Length $= a$

Diameter $= b$

Surface $= S = g +$

$R : r :: c : d$

$R = \frac{rc}{d} \quad d = \frac{rc}{R}$

TAE

Let turns = n

Length = A

Diameter = B

Cross section = $C = \frac{Bc}{4}$

resistance = $R = \frac{A+B}{a+b}\frac{b}{B}r$

E.M.F. = $\mathcal{E} = \frac{A}{a}e$

Surface = $S = \frac{B^2+4AB}{b^2+4ab}\,a$

The cross section of the wire will be

$c : C :: b : B$

$C = \frac{Bc}{b}$ (3)

The change of resistance due to this will be

(4) $R' = \frac{rc}{C} = \frac{cr}{\frac{Bc}{b}} = \frac{br}{B}$

The change of resistance due to the length and diameter will be

$R' : R :: a+b : A+B$

$R = \frac{A+B}{a+b}R'$ (5)

$R = \frac{A+B}{a+b}\frac{b}{B}r$

$\mathcal{E} : e :: A : a$ Same surface speed

$\mathcal{E} = \frac{A}{a}e$

TAE

Surface

$S' : a :: \frac{\pi B^2}{4} + \pi BA : \frac{\pi}{4}b^2 + \pi ba$

$S' = \frac{B^2+4AB}{b^2+4ab}\,a$

No. turns = n wanted
Length = A
Diameter = B.
Cross section = C
Resistance = R
E. M. F. = e Constant
Surface = $S = \frac{B^2 + 4AB}{4} \pi$.
Speed of wire = sp.

Then $A : a :: n : N$

$$A = \frac{an}{N}$$

$$N = \frac{an}{A}$$

Length
Resistance
If other

$n : n :: c : c'$

$$C = \frac{N_c}{n}$$

E. constant
A varying

250

100 Ohm Lamps

		100.	101 Ohms
		1 Ohm 101	
2			
3	1 Ohm	50.24	
		51.24	
4	1 Ohm	34.16	
		35.16	
5	1 Ohm	25.99	
		26.99	
6	1 Ohm	21.26	
		22.26	
7	1 Ohm	18.12	
		19.12	
8	1 Ohm	16.05	
		17.05	
9	1 Ohm	14.56	
		15.56	
10	1 Ohm	13.46	
		14.45	
	10hm	12.62	9
		13.62	
			100 Volts

251

$$\frac{1}{R} = \frac{1}{R'} + \frac{1}{R''}$$

$$R = \frac{R' R''}{R' + R''}$$

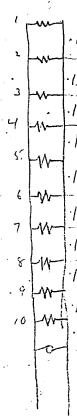
10100

201) 10100 (50.25
1008
500
402
98

150.24) 5124. (34.105
5124
TAE
3

150.24) 5124.0 (34.105
45072
5120
600 96
150 24
8

135.10) 3510.5 (25.99
27020
808 50
675 50
133 000
120 390
12 610



1	10			94.76
2	100.1			94.84
	50.02	50.02	2	
	50.12		2	
3	33.32	33.32	4	95.
	33.49		6	
4	25.1	25.00	10	
	25.2		1	95.3
5	20.11	20.	81	
	20.21		4	95.7
6	16.81	16.66	15	
	16.91		5	96.1
7	14.48	14.28	20	
	14.58		4	96.7
8	12.71	12.5	21	
	12.81		4	97.4
9	11.36	11.11	25	
	11.46		4	98.2
10	10.29	10	29	99.1
	10.39			
			100	

V is Y

$R = \frac{R' \cdot R''}{R' + R''}$

10001	4.0004
5001	2.3012
5002	1.6992
50.12	3.7000
150.12	2.1764
	1.5236
3349.	3.5241
133.49	2.1252
	1.3989
2530.	3.4074
125.3	2.0982
	1.3092
2021.	3.3055
120.21	2.0799
16.81	1.2256
1691.	3.2282
116.91	2.0679
	1.1603
11458.	4.0591
	1.1042
	1.1377

TAE

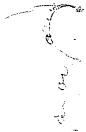
1281 | 3.10077
112.81 | 2.05226
1.05555
38
3.10593
11146 | 2.04770
1.01223
42
1.01165

1.00000
42
.99558
38
.99220
35
.98865
30
.98555
26
.98229
21
.98008
17
.97791
13
.97778
8
.97770

.9778
.9764

The question the mass of the 285-
the [illegible]

Radix [illegible]

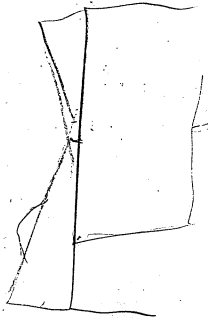


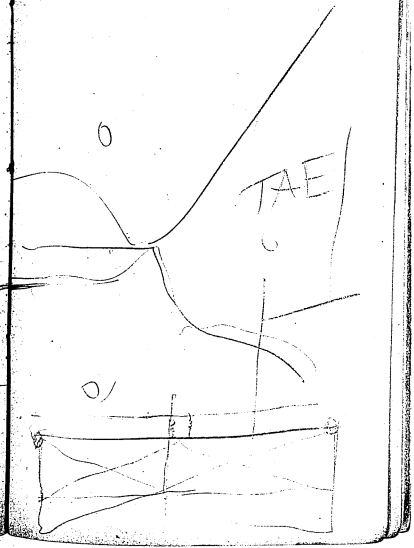
180 Lamps
220 Lamps
320 Lamps

22/665 lbs
30
60 cts.

~~700 feet out~~

490 feet out.





To square 1

1320
185
226
235
29
10
264
61
87
36

9276

235
140

1 foot lb = 0.1380 kilogrammetre.
1 kilogrammetre = 7.2331 ft lbs.
1 Calorie (kilogramme of H_2O heated 1°C.)
4.24 kilogrammetre = 3,9683 heat units Fah

/

5.00 | 165.
.20

TAE

TAE

39 78